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Kameko et al.

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(54) **RESISTOR AND STRUCTURE FOR MOUNTING SAME**

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§ 371 (c)(1),
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H01C 1/142	(2006.01)
H01C 1/144	(2006.01)
H01C 17/28	(2006.01)

(52) **U.S. Cl.**

CPC ***H01C 1/14*** (2013.01); ***H01C 1/142*** (2013.01); ***H01C 1/144*** (2013.01); ***H01C 17/283*** (2013.01)

(58) **Field of Classification Search**

CPC H01C 1/14; H01C 1/142; H01C 13/00
See application file for complete search history.

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(57) **ABSTRACT**

Provided is a resistor for current detection, wherein connection failure etc. due to electro-migration is prevented from being generated in state that the resistor is mounted on a mounting board. The resistor has a resistance body (**11**) and electrodes (**12**). The electrode (**12**) includes first electrode portion (**12***a*) connected to the resistance body (**11**) and second electrode portion (**12***b*) formed on the first electrode portion (**12***a*). The second electrode portion (**12***b*) consists of material having higher resistivity than the first electrode portion (**12***a*) and solder, which is used for mounting the resistor on the mounting board.

3 Claims, 4 Drawing Sheets

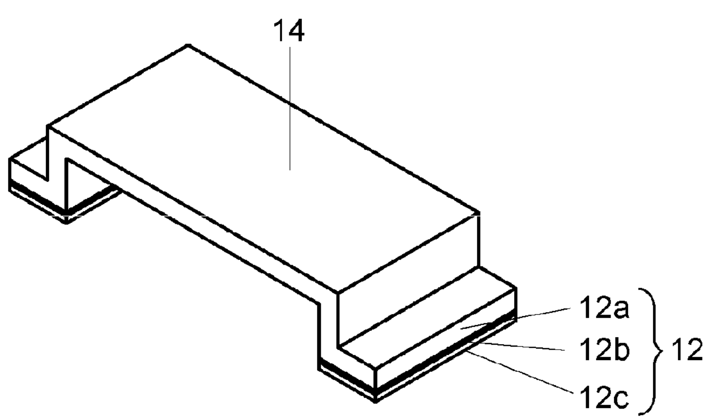


FIG. 1 Prior Art

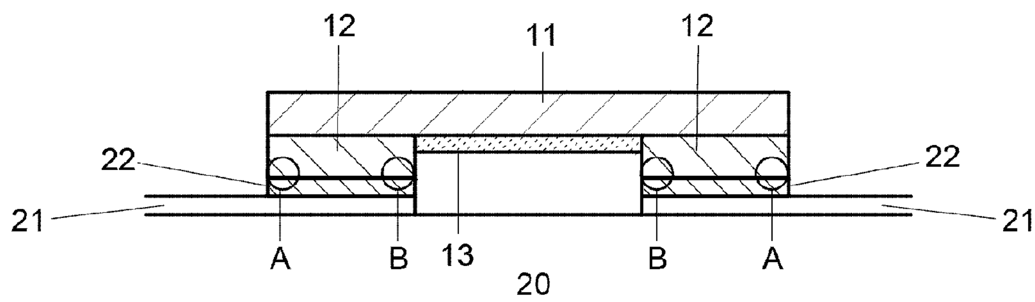


FIG. 2A

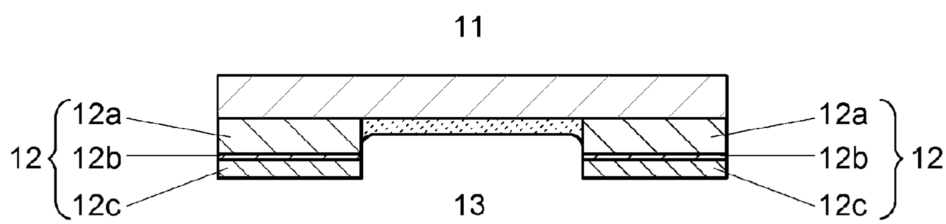


FIG. 2B

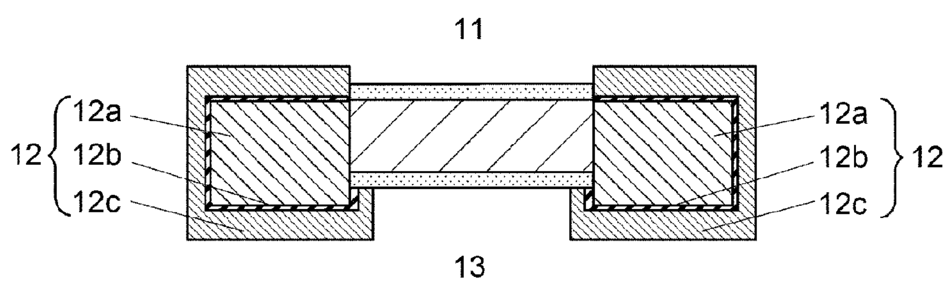


FIG. 3A

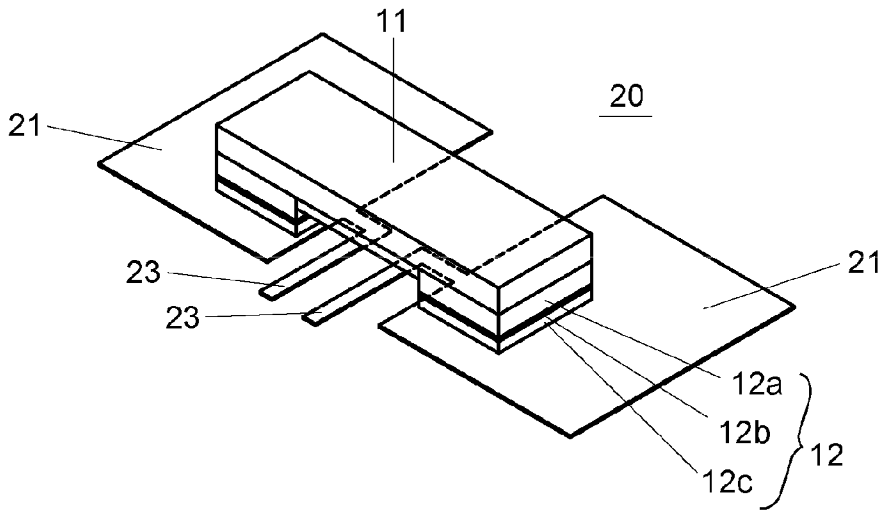


FIG. 3B

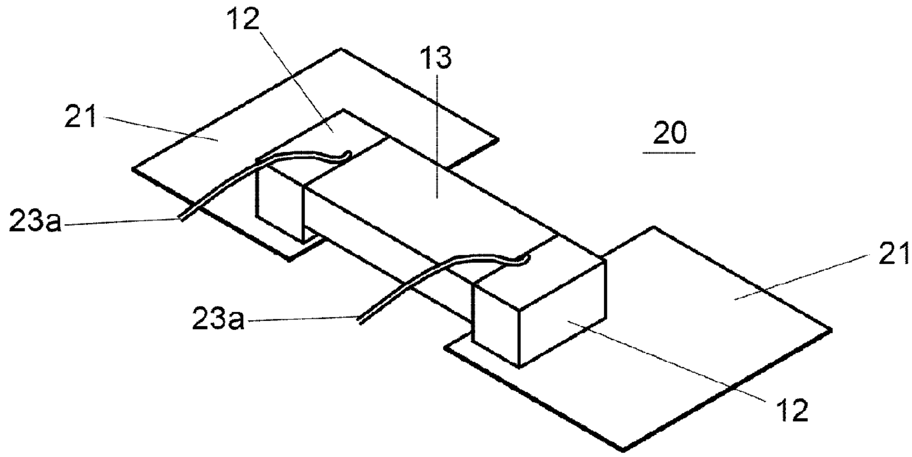
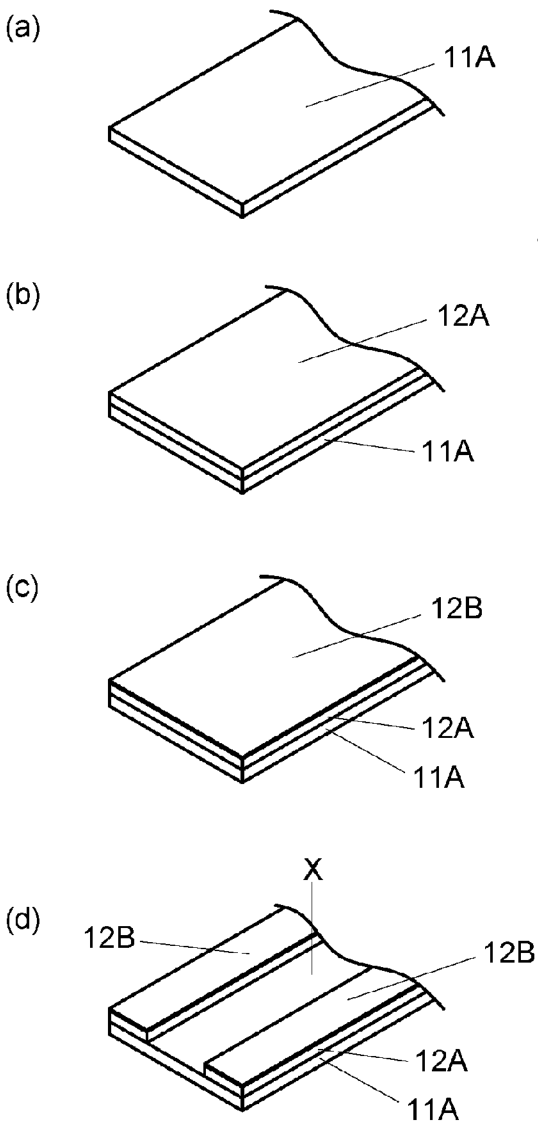


FIG. 4


(a)
11A
(b)
12A
11A
(c)
12B
12A
11A
(d)
X
12B
12B
12A
11A
(e)
12C
12B
11A
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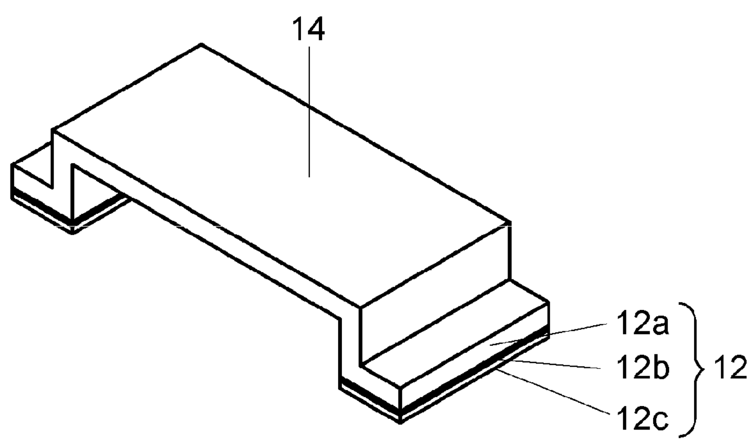
(f)
12c
11
12b
12a
(g)
13
12c
11
12b
12a

FIG. 5



RESISTOR AND STRUCTURE FOR MOUNTING SAME

TECHNICAL FIELD

The invention relates to a resistor and a structure for mounting the same, especially relating to an electrode structure of the resistor for current detection and a structure for mounting the same.

BACKGROUND ART

The resistor for current detection is used, for an example, for monitoring electrical charge and discharge current of a battery, and for controlling electrical charge and discharge current of the battery etc. The resistor for current detection is inserted in the route of the current to be monitored, the voltage caused at both ends of the resistor by the current is detected, and the current is detected from already-known resistance value of the resistor. Though, there are various types of the resistor for current detection, a structure of the resistor is known, as an example. The resistor is provided with electrodes consisting of copper pieces fixed on both ends of lower surface of plate-shaped metal resistance body (refer to laid-open Japanese patent publication 2002-57009).

However, along with miniaturization of electronic equipments, when large current is applied to the miniaturized resistor, there becomes a situation that current density becomes high at mounted section of the resistor. Because of increase of current density, electro-migration is generated at mounted section of the resistor by solder, and there is a possibility that connection failure happens.

FIG. **1** shows mounting situation of conventional resistor for current detection. Copper is generally used as material for electrode **12**, which is disposed at both ends of resistance body **11**. The electrode **12** is fixed onto circuit wiring pattern **21** by solder **22**. In this case, current density becomes high generally at edges of electrode **12** shown by character A or B. Therefore, according to high current density, electro-migration progresses gradually from portion shown by character A or B, and there is a possibility to become a disconnection.

There is a case that voltage detection terminals are pulled out from between a pair of circuit wiring pattern **21**. When electro-migration progresses at a portion shown by character B in FIG. **1**, error voltage detection is caused at vicinity of the portion B, and there is a problem that current detection accuracy becomes harmfully influenced.

SUMMARY OF INVENTION

Technical Problem

The invention has been made basing on above-mentioned circumstances. Therefore object of the invention is to provide a resistor for current detection, wherein connection failure or the like due to electro-migration is prevented from being generated in a state that the resistor is mounted on a mounting board.

Solution to Problem

The resistor having a resistance body and electrodes, comprises: the electrode including first electrode portion connected to the resistance body and second electrode portion formed on the first electrode portion; the second electrode portion consisting of material having higher resistivity than the first electrode portion and having higher resistivity than solder, which is used for mounting the resistor on a mounting board.

According to the invention, since the second electrode portion is provided, it contributes to making current density distribution from solder to inside of electrode uniform, and it decrease current concentration at end portion of the electrode. Therefore, tolerance of the resistor for current detection can be improved against electro-migration, which is generated when mounted.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a cross-sectional view of conventional resistor at mounted state.

FIG. **2**A is a cross-sectional view, which shows a resistor according to first embodiment of the invention.

FIG. **2**B is a cross-sectional view, which shows a resistor according to second embodiment of the invention.

FIG. **3**A is a perspective view, which shows mounted state of the resistor according to first embodiment.

FIG. **3**B is a perspective view, which shows mounted state of the resistor according to second embodiment.

FIG. **4** is a perspective view, which shows manufacturing process of the resistor according to first embodiment.

FIG. **5** is a perspective view of an example, wherein electrode structure of the invention is applied to a jumper chip.

DESCRIPTION OF EMBODIMENTS

Embodiments of the invention will be described below with referring to FIG. **2**A through FIG. **5**. Like or corresponding parts or elements will be denoted and explained by same reference characters throughout views.

A resistor shown in FIG. **2**A is a resistor for current detection, which has resistance body **11** and electrodes **12** fixed at both ends of lower surface of the resistance body. Resistance body **11** uses resistive material of low resistivity and excellent temperature coefficient of resistance, consisting of copper-nickel system alloy, nickel-chrome system alloy etc. Electrode **12** is provided with first electrode portion **12***a*, second electrode portion **12***b*, and third electrode portion **12***c*. Copper, which is highly conductive material, is used for first electrode portion.

Electrode structure of the invention is characterized in that second electrode portion **12***b* consists of higher resistivity material than first electrode portion **12***a* and third electrode portion **12***c*. For example, an alloy of nickel-chrome or nickel-phosphorus system, which has higher resistivity than copper for first electrode portion and tin for third electrode portion, is used for second electrode portion **12***b*.

Nickel-chrome system alloy is used for second electrode portion **12***b* in the example shown in FIG. **2**A. As the example, metal material, which is used for resistance body, may be used for second electrode portion **12***b*. Higher resistivity layer intervenes as second electrode portion **12***b*, and then current density distribution in electrode **12** and inside of solder between resistance body **11** and wiring pattern **21**, becomes uniform.

Solder material of tin system is used for third electrode portion **12***c* for securing mounting ability such as solder wet-characteristics. Solder material, which is used generally, can be used for third electrode portion **12***c*. Lead-free solder such as Sn system, Sn—Ag system, or Sn—Cu system, or solder such as Sn—Pb system also can be used. Further, in case that familiar material with solder such as copper-nickel system alloy, for an example, is used for second electrode portion **12***b*, third electrode portion may not be provided.

As to electrical resistivity of metals, which are used for electrodes, copper for first electrode portion is 1.7 μΩ·cm, tin for third electrode portion is 10.9 μΩ·cm, nickel-chrome system alloy for second electrode portion is about 108 μΩ·cm, and nickel-phosphorus system alloy for second electrode portion is about 90 μΩ·cm. As to electrical resistivity of metals for resistance body, copper-nickel system alloy is 49 μΩ·cm, and nickel-chrome system alloy is 108 μΩ·cm. Further, electrical resistivity may be different from above-mentioned numerals according to contained metal components.

As to relation of thickness of each layer of electrode **12**, thickness of first electrode portion **12***a* is about 200 μm, thickness of second electrode portion **12***b* is about 5-10 μm, and thickness of third electrode portion **12***c* is about 3-12 μm. It is preferable that second electrode portion **12***b* is formed more thinly than first electrode portion **12***a* and third electrode portion **12***c*.

FIG. **3**A shows structure that the resistor shown in FIG. **2**A is mounted on a mounting board. Second electrode portion **12***b* bonded on first electrode portion **12***a* and third electrode portion **12***c* consisting of tin system solder intervene between first electrode portion **12***a* and wiring pattern **21**. The resistor is fixed on wiring pattern **21** formed on mounting board **20** by using solder.

Further, solder material is formed beforehand on wiring pattern **21** at a position, where electrode **12** is to be fixed (not shown). The solder material and third electrode portion **12***c* are generally consisting of same tin system metal material. When resistor is mounted, the solder material and third electrode portion **12***c* on wiring pattern **21** are melt by reflow. Accordingly, there becomes no distinction between solder formed on wiring pattern **21** and third electrode portion **12***c*, then mounting state that solder intervenes between second electrode portion **12***b* and wiring pattern **21**, is obtained.

According to the invention, second electrode portion **12***b* consisting of metal material having higher resistivity than solder and first electrode portion **12***a* intervenes between the solder and the portion **12***a*. Then, it makes current density distribution inside of electrode **12** and solder uniform, and current concentration to edge portion of electrode **12** becomes reduced (the portion where character A, B shows in FIG. **1**). As a result, according to the electrode structure of the invention, it can make the resistor having high tolerance against electro-migration.

In state of being mounted, it is preferable that thickness of second electrode portion **12***b* becomes 1/10 or less of total thickness of solder including solder formed on wiring pattern **21** and third electrode portion **12***c* (formed by reflow at mounted state). As a result, even in case of taking voltage detection terminal **23** at a pair of portion where wiring pattern **21** opposes, generation of error voltage caused by second electrode portion **12***b* having relatively high resistance, can be stopped at least.

FIG. **2**B shows a resistor for current detection of second embodiment of the invention, and FIG. **3**B shows its mounted state. The resistor has a structure that electrodes **12** are fixed at both end faces of resistance body **11** in lengthwise direction. The electrode **12** has first electrode portion **12***a* of high conductivity material consisting of copper, second electrode portion **12***b* of relatively high resistivity material consisting of nickel-chrome system or nickel-phosphorus system alloy etc., and third electrode portion **12***c* of high conductivity material consisting of tin.

In the example shown in FIG. **2**B, nickel-phosphorus alloy film formed by electrolytic plating is used for second electrode portion **12***b*. Third electrode portion **12***c* is a film consisting of tin formed by electrolytic plating. Outer surfaces (upper and lower surfaces and both side surfaces) on resistance body **11** other than joint surface with electrode **12***a* is covered by insulative protective film **13** such as epoxy resin etc. As well as first embodiment, bottom surface of third electrode portion **12***c* is mounted on wiring pattern **21** of mounting board **20** by solder joint. In the embodiment, voltage detection terminal **23** is not taken from wiring pattern **21**, but is fixed by wire bonding on upper surface of electrode **12**. Further, according to kinds of wire for wire bonding, material for third electrode portion may be changed to nickel etc., for an example.

In the embodiment, since resistivity of second electrode portion **12***b* is higher than solder and copper, density distribution of current flowing through electrode **12** between wiring pattern **21** and resistance body **11** becomes unified. As a result, high current density portion, which is shown by character A or B in FIG. **1**, becomes dissolved. And, as well as first embodiment, the resistor can be made to have high tolerance against electro-migration.

Second electrode portion **12***b* covers exposed area of first electrode portion **12***a*. Third electrode portion **12***c* is formed on exposed metal area that is other than area, where protective film **13** covers, by electrolyte plating method etc. Therefore, when mounting, solder such as tin etc. can be prevented from connecting to first electrode portion **12***a* by second electrode portion **12***b* intervening. Further, in the embodiment, since voltage detection terminal **23***a* is not taken from wiring pattern **21**, but taken from upper surface of first electrode portion **12***a*, there is an advantage that voltage between both ends of resistance body **11** can be detected accurately without receiving influence of voltage caused by second electrode portion **12***b* of high resistivity.

Next, manufacturing process for resistor of first embodiment of the invention will be described referring to FIG. **4**. First, plate material **11**A of long size consisting of resistive material such as copper-nickel system alloy is prepared (refer to (a)). And, plate material **12**A of copper to be first electrode portion is lapped on plate material **11**A (refer to (b)). Further, plate material **12**B of nickel-chrome system alloy to be second electrode portion is lapped over there, and cladding material of three layers, where layers are diffusion bonded, is formed by applying pressure and heat (refer to (c)).

Next, a portion of copper plate material **12**A and nickel-chrome plate material **12**B shown by character X is removed by machining. As a result, portions of copper plate material **12**A and nickel-chrome plate material **12**B are formed so as to be separated on both sides of resistive plate material **11**A (refer to (d)). And, tin film **12**C to be third electrode portion is formed on surface of nickel-chrome plate material **12**B by dipping surface of the plate material **12**B into melt solder in a tank, for an example (refer to (e)). Further, in case of third electrode portion unnecessary, process (e) may be omitted.

Next, above-formed long size plate material is cut into pieces, each corresponding to a resistor. As a result, the resistor having an electrode **12** consisting of first electrode portion **12***a*, second electrode portion **12***b*, and third electrode portion **12***c*, on both ends of plate shaped resistance body **11** is formed (refer to (f)). And, insulative material **13** is formed on exposed surface of resistance body **11** between electrodes **12** at both ends by applying paste such as epoxy resin and heating to be hardened. As a result, the resistor, which is provided with an electrode structure of the invention shown in FIG. **2**A, is completed (refer to (g)).

Further, resistor of second embodiment can be manufactured by fixing electrode **12***a* of copper piece to both end faces of square pillar shaped resistance body **11** in lengthwise direction by abutting and diffusion bonding, covering outer surfaces of resistance body **11** with insulative material **13** such as epoxy resin etc., and forming second electrode portion **12***b* of relatively high resistivity film and third electrode portion **12***c* of tin film by electrolyte plating.

FIG. **5** shows an example of jumper chip, which has the electrode structure of the invention. Electrode portion **12** of jumper chip **14** consisting of resistive material such as copper-nickel system alloy etc. has second electrode portion **12***b* of relatively high resistivity and third electrode portion **12***c* of high conductivity such as tin at bottom surface thereof. As a result, current density distribution can be uniformed at inside of electrode **12**, and tolerance against electro-migration can be improved as well as before-mentioned each embodiment.

Although embodiments of the invention has been explained, however the invention is not limited to above embodiments, and various changes and modifications may be made within scope of the technical concept of the invention.

INDUSTRIAL APPLICABILITY

In case of making a resistor for current detection smaller, electrode mount area becomes smaller, and then electro-migration becomes problem. Therefore, the invention can be useful for high power surface-mount type resistor.

The invention claimed is:

1. A resistor having a resistance body and electrodes, comprising:

the electrode including first electrode portion connected to the resistance body and second electrode portion formed on the first electrode portion;

the second electrode portion consisting of material having higher resistivity than the first electrode portion and having higher resistivity than solder, which is used for mounting the resistor on a mounting board.

2. The resistor according to claim **1**, wherein the electrode further includes third electrode portion, and wherein the second electrode portion intervenes between the first electrode portion and the third electrode portion, and resistivity of the material of the second electrode portion is higher than that of the third electrode portion.

3. A structure for mounting a resistor having a resistance body and electrodes on circuit wiring pattern formed on a mounting board, comprising:

the electrode including first electrode portion connected to the resistance body and second electrode portion formed on the first electrode portion;

the second electrode portion and solder intervening between the circuit wiring pattern and the first electrode portion; and

the second electrode portion consisting of material having higher resistivity than the first electrode portion and the solder used for mounting the resistor on the mounting board.

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